## CHAPTER II

### Literature Review

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It has been found that there are several studies on the different fish species about their abundance, and nutritional and biochemical compositions that had been reported from the various parts of the world. The reported works on the different fish species from the globe are highlighted herein in this chapter of the thesis.

Hussain (2012) studied the ichthyofauna and limnology of the River Barak, Jatinga, Dholeswari and Ganol in North East India. In this, Geographical coordinates were recorded using hand held Garmin GPS-60 and identification was done at Zoological Survey of India, Shillong. They reported a total of 103 individuals including 5 species of mahseers under 57 genera belonging to 24 families and 10 orders. A total of 87 species from river Barak, 51 species from river Jatinga, 40 species from river Dhaleswari and 10 species from river Ganol were recorded during their study period. They observed that the limnological parameters did not display unexpected fluctuation with air temperature (25–30 $^{o}$C), water (24–26$^{o}$C), pH (6.56–9.58), conductivity (63–165.63 µmho/cm), dissolved oxygen (5.42–7.61 mg/L), free $CO_2$ (7.25–28.47 mg/L), total alkalinity (20–121.95 mg/L), except the major water quality like pH and dissolved oxygen. All the other parameters supported mahseer fishery in these rivers mainly in Ganol and Barak.

Acharjee et al. (2014) studied the ichthyodiversity dynamics in a hill stream of the Darjeeling Himalaya, West Bengal (India). They recorded a total of 25 fishes belonging to five families *viz. Cyprinidae, Psilorhynchidae, Balitoridae, Cobitidae, Sisoridae* and 16 genera. It was observed that fish species belonging to the family of *Cyprinidae* were observed to be the highest in their study. They also reported that diversity and abundance indices sharply increased during October–November and slightly during April–May. So, they concluded that the diversity and density of fish accumulations may be disturbed due to anthropogenic activities.

Valentina et al. (2015) studied the assessment of physico-chemical characteristics and fish diversity from three sites of hill streams *viz.* Longnit River, Jamuna River, Amreng River of Karbi Anglong district, Assam, India. They recorded a total of 62 species of fish represented by 7 orders (*Cypriniforms, Siluriformes, Perciformes, Anguilliformes, Beloniformes, Synbranchiformes* and *Tetraodontiformes*), 15 families *viz. Anguillidae, Cyrinidae, Psilorhynchidae, Nemacheilidae, Botiidae, Cobitidae, Amblycipitidae, Erethistidae, Sisoridae, Belonidae, Mastacembelidae, Badidae, Gobiidae, Channidae, Tetradontidae* and 32 genera in their study. They observed that Shannon-Weiner diversity index of fish ranged from 3.28 to 3.88 which is indicative of rich fish diversity.

Baro et al. (2015) studied the diversity and abundance of coldwater fishes of Sonkosh River, Kokrajhar, Assam. They recorded a total of 65 fish species belonging to 6 major orders and 18 families. The occurrence of the fish species belonged to the following orders: *Anguilliformes, Cypriniformes, Siluriformes, Beloniformes, Perciformes and Tetraodontiformes*. Out of 65 species, 29 belonged to the family *Cyprinidae* (29) and followed by *Sisoridae* (7), *Nemacheilidae* (6), *Cobitidae* (4), *Channidae* (3), *Psilorhynchidae* (2), *Olyridae* (2), *Badidae* (2), *Anguillidae* (1), *Amblycipitidae* (1), *Bagridae* (1), *Siluridae* (1), *Schilbeidae* (1), *Eresthistidae* (1), *Belonidae* (1), *Mastacembelidae* (1), *Nandidae* (1) *and Tetradontidae* (1) were reported. They suggested that understanding of ichthyofaunal diversity of Sonkosh river as well as other rivers of Indo-Bhutan foothill is critically needed.

Plamoottil (2016) discussed systematic studies on the hill stream *Cyprinid* fishes of Manimala River of Kerala, India. The fish species were collected by using gill net, cast net, madavala, vattavala etc. A total of 12 species of fishes *viz. S. boopis, B. bakeri, D. aequipinnatus, D. malabaricus, R. daniconius, P. mahecola, H. fasciatus, D. filamentosa, G. kurali, Garra mully, M. triangularis* and *B. australis* belonged to the 11 genera *viz. Salmostoma, Barilius, Devario, Dawkinsia, Rasbora, Puntius, Gonoproktopterus, Garra, Haludaria, Mesonoemacheilus* and *Bhavania* and 03 families *viz. Danionidae, Cyprinidae, Balitoridaewere* were recorded. Results showed that *Dawkinsia* was the edible *Cyprinid* fish abundantly distributed in all high-level regions of the River.

Bhusal and Chitrakar (2017) studied the taxonomy and fish diversity of some fishes from Roshi khola, Panauti, Nepal. They reported a total of 5 fish species *viz. Schizothorax plagiostomus, Schizothoraichthys labiatus, Schistura rupecula, Schistura beavani, Glyptosternum maculatum* under two orders (*Siluriformes, Cypriniformes*), three families (*Cyprinidae, Siluridae, Cobitidae*) and four genera (*Schizothoraichthys, Schistura, Schizothorax, Glyptosternum*). It was observed that the most commonly distributed fish species in the Roshi khola was *Schizothorax plagiostomus*.

Badoni (2018) studied the fish diversity of hill stream Dhundeshwer Gad, Uttarakhand, India, along with its conservation status. They recorded a total of 19 fish species *viz. Barilius* *barna, Barilius vagra, Barilius bendelisis, Tor chelynoides, Tor tor, Tor putitora, Crossocheilus latius latius, Garra lamta, Garra gotyla gotyla, Nemacheilus botia, Schizothorax richardsonii, Schizothorax plagiostomus, Nemacheilus montanus, Nemacheilus rupicola, Nemacheilus multifaciatus, Nemacheilus zonatus, Glyptothorax madraspatanum Glyptothorax pectinopterus* and *Pseudecheneis sulcatus* which belonged to 2 orders (*Cypriniformes* and *Siluriformes*) and 3 families (*Cyprinidae, Balitoridae* and *Sisoridae*). They observed the highest diversity in the monsoon season.

Bhata (2003) studied the diversity and composition of freshwater fishes from four Rivers *viz*. Sharavati, Aghanashini, Bedti and Kali of the Central Western Ghats, India. Results recorded a total of 92 species which belonged to 25 families, *Cyprinidae, Balitoridae, Bagridae, Candidae, Gerreidae, Gobidae, Mugilidae, Siluridae, Carangidae, Poecilidae, Cichlidae, Eleotridae, Ariidae, Cobitidae, Aplocheilidae, Megalopidae, Hemiramphidae, Channidae, Nandidae, Mastacembelidae, Tetraodontidae, Syngnathidae, Belonidae, Sisoridae, Claridae* and 48 genera. They mentioned the comparison of expected species richness (SR) estimates using different statistical estimators and showed that the expected SR be in the range of 92–120 species.

Bisht et al. (2009) studied the relative abundance and seasonal distribution of fish fauna of hill stream Dangchaura Gad (Takoli) and River Alaknanda. They recorded 21 fish species that belonged to 2 orders (*Cypriniformes* and *Siluriformes*) and 3 families (*Cyprinidae, Balitoridae* and *Sisoridae*) in their study paper. They mentioned that the availability of fish-fauna was directly related to the nature of profile and slope of the tributary which affects the migration and breeding grounds of the fishes inhabited.

Sluka et al. (2010) studied the relative abundance and diversity of Grouper (*Pisces: Serranidae*) of the West Coast of India. They found a total of eighteen grouper species with two new records *viz. Plectropomusareolatus* and *Aethalopercarogaa* and observed that the most dominant species were *Epinephelus faveatus* and *Cephalopholis formosa.*

Vijaylaxmi and Vijaykumar (2011) studied the biodiversity of the fish fauna of the Bheema River in Gulbarga district of Karnataka and reported a total of 29 fish species that belonged to 6 orders. They studied fish diversity by determining the diversity indices such as Shannon-Weiner biodiversity index, Pielou's evenness, Simpson's index of diversity and Margalef index of species richness, and concluded that the dominant order was *Cypriniformes* with 16 species followed by *Siluriformes* order with 5 species, *Channiformes* and *Perciformes* with 3 species, *Mastacembeliformes* and *Osteoglossiformes* each with one species.

Sarkar et al. (2012) studied the fish biodiversity including changing patterns, threats and conservation status from the River Ganga (India). Here, relative abundance (percentage of catch) of fish across different sites was calculated and diversity indices Shannon and Wiener index, Jacquard's index was observed. They recorded a total of 143 freshwater fish species belonging to 11 orders, 72 genera and 32 families, which was about 20 % of freshwater fish of the total fishes reported in India. They observed high species richness in the orders of *Cypriniformes, Siluriformes* and *Perciformes*. The family *Cyprinidae* (53.47 %), *Bagridae* (8.46 %) and *Channidae* (1.47 %) were found to be the most dominant in the Ganges and also first time reported 10 exotic fishes in India, including *Pterygoplichthys anisitsi*. They also listed 29 species under the threatened category.

Das and Sharma (2012) studied the comparison of fish diversity of Kopili and Jamuna Rivers of Karbi Anglong District, Assam. They reported a total of 61 *piscine* species belonging to 7 orders, 16 families and 35 genera. 54 fish species were reported from River Kopili and 47 were reported from Jamuna River during the study period. Out of them, 11 species were abundant in both the rivers. They also found the most abundant species as per order were *Cypriniformes, Siluriformes and Perciformes.* As per genera and species, family *Cyprinidae* was maximum diversity amongst all the families.

Basavaraja et al. (2014) studied the abundance and fish diversity in respect of water quality of Anjanapura reservoir, Karnataka (India). This study reported 25 fish species that belonged to 09 families, 04 orders and 18 genera. The *Cypriniformes* order was the predominant with 14 species followed by *Siluriformes* order with 6 species, *Perciformes* order with 4 species and one species of *Osteoglossiformes*. They also reported the conservation (IUCN-1994) status of the reported fishes and it showed that out of 25 fish species, 11 species were categorized into lower risk near threatened, 08 not assessed, 03 vulnerable, 01 of endangered category.

Khomdram et al. (2014) studied the ornamental fish species available in the Jiribam sub-division, Imphal East district, Manipur, India. They reported a total of 139 ornamental fishes in the state of Manipur and from these 61 species were found from the surveyed area which belonged to 22 families and 7 orders. They also reported the conservation status of the reported fishes and found that out of the 61 species of ornamental fishes, 42 species were recorded as threatened species and 3 species were endemic. They concluded that the percentage contributions of *Cyprinids* were found to be 33.3 % being the dominant family in their study.

Mohanty et al. (2015) studied the abundance and diversity of fish species of Chandipur, Bay of Bengal, India. They recorded 21 species/groups that belonged to the family *Clupeidae, Chirocentridae, Engraulidae, Herpadontidae, Mugillidae, Ariidae, Polynemidae, Scianidae, Sillaginidae, Stromatidae, Scrombidae, Forminidae, and Centopomidae*. The most common abundant families were *Clupeids, Sciaenids, Stromatids, Polynemids* and *Arrids* that shared about 87% of annual the total fishery.

Arif et al. (2019) studied the distribution and abundance of indigenous ornamental fishes across the tributaries of three rivers *viz.* Chenab, Tawi and Basantar, Jammu and Kashmir of India. They reported a total of 30 species belonging to 8 families and 18 genera. It was concluded that *the Cyprinidae* family was found to be dominant with the highest percentage occurrence (85 %) followed by family *Bagaridae* (11 %), *Channidae* (10 %), *Mastacembelidae* (10 %), *Neamchilidae* (4 %), *Heteropneustidae* (3 %), *Badidae* (1 %) and *Osphronemidae* (1 %).

Kulabtong and Mahaprom (2016) surveyed the hill stream fishes in Upper Cyber Stream, outside Huai Kha Khaeng Wildlife Sanctuary, West Thailand. They recorded a total of 6 orders (*Cypriniformes, Siluriformes, Beloniformes, Synbranchiformes, Cyprinodontiformes, Perciformes*), 9 families (*Cyprinidae, Balitoridae, Cobitidae, Bagridae, Belonidae, Mastacembelidae, Poeciliidae, Ambassidae, Nandidae*) and 22 species of hill stream fishes *viz. Danio albolineatus, Rasbora paviana, Rasbora borapetensis, Mystacoleucus marginatus, Barbodes rhombeus, Neolissochilus stracheyi, Osteochilus vittatus, Garra cambodgiensis, Garra nasuta, Schistura desmotes, Homalopteroides smithi, Pseudohomalopteracf. Leonardi, Lepidocephalichthys berdmorei, Batasio tigrinus, Pseudomystus siamensis, Hemibagrus nemurus, Xenentodon cancila, Mastacembelus favus, Poecilia reticulate, Parambassis siamensis, Pristolepis fasciata* and *Channacf gachua*.

Fynn and Mensah (2012) studied the fishery diversity and relative abundance from Winneba to Cape Coast, Ghana. They found 56 species of 30 families. The main species occurred were of families *Carangidae, Clupeidae, Haemulidae* and *Sciaenidae*. The relative abundance of the organisms was *Chloroscombrus chrysurus* (26.0 %), *Selene dorsalis* (11.2 %), *Brachydeuterus auritus* (22.8 %), *Ilisha africana* (14.7 %) and *Sardinella aurita* (13.1 %).

Ataguba et al. (2014) studied the fish species diversity and abundance of Gubi Dam in Bauchi State, Nigeria. They recorded a total of 18 fish species which belonged to 6 families *viz. Mormyridae, Alestidae, Claridae, Mochokidae, Cyprinidae, Cichlidae.* Results showed that the most abundant family was *Cichlidae* (61.51 %) with the species *S. galilaeus* being the most abundant (34.88 %) while the family *Mochokidae* was the least abundant (1.45%) and is represented by only one species.

Hashemi et al. (2015) studied the composition, distribution and abundance of fish species in Shadegan Wetland from five different stations; Salmane, Rogbe, Mahshar, Khorosy and Ateish. They recorded a total of 3312 fish individuals comprising 26 species from 6 families and concluded that the most abundant species was *Carasobarbus uteus* (*Cyprinidae*) comprising 28.20 % of the total fish caught followed by *Cyprinus carpio (Cyprinidae*) (18.50 %) and *Carasius carasius (Cyprinidae*) (13.19 %). Maximum and minimum abundant families were *Cyprinidae* (82.91 %) and *Engralidae* (0.5 %) respectively. They also observed the maximum Shannon-Weinner value in spring and minimum in autumn.

Tessema and Mohamed (2016) studied the composition and relative abundance of fish species from Gerado and Dirma Rivers, South Wollo, Ethiopia. They observed that the most dominant fish species in Dirma and Gerado Rivers in dry season was *Varcohinus beso* with a total number of 128 and 129 respectively and the most dominant fish species in wet season in Dirma River was *Labeobarbus intermedius* (40 numbers) whereas *Varcohinus beso* was dominant in Gerado River (25 numbers). They also observed that the total fish specimen in Drima River was 236 in dry season than wet season (77 numbers) and Gerado River was 199 in dry season than wet season (37 numbers).

Chow et al. (2016) studied the composition and abundance of freshwater fishes in selected four rivers *viz*. Sungai Dengar, Sungai Mengkibol, Sungai Madek and Sungai Ulu Dengar of Johor, Malaysia. They recorded a total of 1124 juvenile and adult individuals, indicating 35 fish species from 13 different families. The predominant families in the sampling sites were *Cyprinidae* family with 20 species (54.29 %), which is followed by *Mastacembelidae* family with 3 species (8.57 %), *Hemiramphidae* and *Channidae* family with each of 2 species (5.71 %). The other families represented were of 1 species each *viz. Cichlidae, Bagridae, Claridae, Gobiidae, Cobitidae, Loricariidae, Sisoridae, Synbranchidae* and *Poecilidae* (2.86 % each).

Ahmed et al. (2018) studied the freshwater fish diversity, abundance and the heightening effect of the Roseires reservoir, Blue Nile State of Sudan. They recorded a total of 34 species belonged to 13 families. Among identified fishes, family belonging to *Mormyridae* was dominated (7 species) followed by *Characidae* (6 species), *Cyprinidae* (5 species), *Bagridae* (4 species), *Schilbeidae* (3 species) and *Cichlidae* with two species. Based on relative abundance of fish species, *Synodontis* species was dominant (42.43 %) followed by *Latesniloticu* (12.06 %) and *Oreochromisniloticus* (6.17 %).

Parvathy (2018) studied the abundance and fish diversity of Thrissur kole wetlands, Ramsar site. They reported a total of 29 fish species belonging to 13 families and 7 orders. *Cypriniformes* was the most abundant and dominant order followed by *Perciformes* and *Siluriformes*. Their conservation status (IUCN) were also mentioned and fish diversity of includes 2 species of EN, 5 species of VUL, 21 species of LC, and one fish species of near threatened.

Paul et al. (2016) studied the fatty acid, amino acid and fat-soluble vitamins of *Clarias batrachus* (Magur) and *Heteropneustes fossilis* (Singhi) fishes. They reported that the essential amino acid (EAA) and the non-essential amino acid (NEAA) contents in Magur and Singhi did not show significant differences. The Vitamin A and D contents were significantly higher in Magur in comparison to Singhi. The Vitamin K content was significantly higher in Singhi compared to Magur. Monounsaturated fatty acid (MUFA) contents were 38.34 ± 4.62 % and 49.69 ± 7.82 % in Magur and Singhi, respectively. The polyunsaturated fatty acid (PUFA) contents were 25.52 ± 1.40 % and 13.86 ± 0.64 % in Magur and Singhi respectively. The eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) contents were 2.98 ± 1.00 %, 3.60 ± 1.11 % and 2.25 ± 0.86 %, 1.60 ± 1.09 % respectively in Magur and Singhi. The ω-3: ω-6 ratio in Magur was 0.45:1 and in Singhi it was 0.82:1. They concluded that both the catfishes were found to be nutrient-rich with amino acid, fatty acid and vitamins.

Dey and Goswami (2016) studied vitamin A content, nutritional value and seasonal variation of proximate composition of Indian Major Carps. They selected three species of Indian Major Carp *viz. Labeo rohita, Catla catla, Cirrhinus mrigala* from Brahmaputra. Results showed that there were no much significant seasonal variations in the body composition of Indian Major Carp. The vitamin content ratio of retinol: dehydroretinol was not shown much difference and the lipid content was comparatively low with the lowest in *Labeo rohita* but lipid subclasses vary in different parts of the body of the same fish species. They also reported that protein content showed the maximum in *Cirrhinus mrigal* in comparison to the other two species.

Singh and Ranjan (2016) reported a comparative study on macro and micro nutrient profiles of selected brackish, marine water and freshwater fishes from Kerala, India. They determined the composition such as moisture (%), fat (%), crude protein (%), ash (%), fatty acid profile, amino acid profile and mineral contents. From this study, they mentioned that fish species are good sources of minerals, protein, essential fatty acids and essential amino acids which can be consumed and used as a good diet of human being.

Paul et al. (2018) studied nutrient profiles of 5 fresh-water fishes *viz. Ompok bimaculatus, Mystus vittatus, Channa striata, Pangasianodon hypophthalmus* and *Wallago attu* from West Bengal and Odisha. Results showed that the moisture was higher in *C.striata (*76.11 ± 0.17 %), fat concentration was higher in *P. Hypophthalmus (*7.17 ± 0.39 %) and *M.vittatus* (6.91 ± 0.18 %), the total crude protein content of five freshwater fish species ranged from 13.93 to 15.41 % of fresh weight and ash content ranged from 1.88 to 2.57%. The K concentration was higher in *C. striata* (170.60 ± 4.95 ppm), Na concentration was higher in *P. hypophthalmus* (51.65 ± 3.88 ppm), but calcium content was higher in *M.vittatus* that ranged from 150 to 255 mg/100 g. The other trace minerals like iron, copper and zinc contents of fish did not differ significantly among the species. The amount of vitamin A was noticed to be higher in *O.bimaculatus* that ranged from 5.0 to 1058.0 μg/100 g, whereas vitamin D content was found to be higher in *Mystus vittatus* which ranged from 5.0 to 384.0 μg/100 g. Docosahexaenoic acid (DHA) concentration varied from 0.31 ± 0.15 % to 4.80 ± 1.87 %. The PUFA concentration was higher in *O. bimaculatus* (27.49 ± 4.34 %) and *P.hypophthalmus* (21.59 ± 0.31 %). Among the amino acids, threonine, arginine, histidine and isoleucine were found to be higher in *P.hypophthalmus*. The total energy content ranged from 504-591 kcal/ 100 g and it was the maximum in *P. hypophthalmus*.

Borah (2019) studied different need-based technologies, tools for the harvesting, preparation and the preservation of indigenous fishes by traditionally and investigated nutritional compositions. He reported ranges of nutritional composition data such as moisture 75–81 %, ash 1.95–4.31 %, protein 13–15 %, fat 1.18–5.78 %, energy 52.14–114.02 kcal/g, potassium 78.29–501.47 mg/100 g, sodium 124.85–581.92 mg/100 g, calcium 76.59–1984.32 mg/100 g, magnesium 81.55–148.16 mg/100 g, iron 0.31–15.95 mg/100 g, zinc 13.15–27.06 mg/100 g, manganese 0.02–6.34 mg/100 g. He also mentioned that small indigenous fishes are chosen by the ethnic community of the region because of their exceptional food value and taste, and were consumed in different forms such as in fresh, dried and fermented form.

Mohanty et al. (2016) studied the fatty acid profiles and proximate composition of 39 fish species of India including edible mollusks, shellfishes and finfishes from both fresh water and marine water. It was reported that migratory fish *T. ilisha* exhibited the highest amount of fat (10.5 %) followed by the marine fish *S. longiceps* (9.2 %). The study showed that fish species viz. *Sardinella longiceps, Tenualosa ilisha, Anabas testudineus* and *Nemipterus japonicus* were rich sources of Eicosapentaenoic acid (EPA) and DHA.

Dhaneesh et al. (2012) studied nutritional composition of ten edible marine fish species *viz. Carangoides orthogrammus, Epinephelus tauvina, Tylosurus crocodilus crocodiles, Seriola lalandi, Lutjanus gibbus, Hyporhamphus dussumieri Parupeneus bifasciatus, Thunnus albacares, L. bohar, Chelinus undulates* from Agatti Island water, Lakshadweep Sea. The results of proximate composition such as ash, lipid, carbohydrate, and protein were high in *T. albacares* (1.65 %), *Hyporhamphus dussumieri* (6.97 %), *Parupeneus bifasciatus* (6.12 %), and *Thunnus albacares* (13.69 %), respectively. Major amino acids determined were lysine (2.84–4.56 %), leucine (2.67–4.18 %) and methionine (2.64–3.91 %). The fatty acid contents varied from 31.63 % to 38.97 % SFA (saturated fatty acid), 21.99–26.30 % MUFAs (monounsaturated fatty acids), 30.32–35.11 % PUFAs (polyunsaturated fatty acids) and 2.86–7.79 % branched chain fatty acids. The PUFAs ω-3 and ω-6 were found in the ranged of 13.05–21.14% and 6.88–9.82 %, respectively.

Romharsha et al. (2014) studied amino acid and proximate composition of 3 hill stream fish species *viz. Semiplotus manipurensis, Neolissochilus stracheyi* and *Labeo pangusia* of Manipur. They recorded that crude protein was found in between 19.00 ± 0.92 to 20.64 ± 0.03 ranges. The total lipid was recorded to be the highest in *S. manipurensis* (3.56 ± 0.04) and lowest being in *L. pangusia* (2.45 ± 0.02). The moisture was reported in the range from 72.80 ± 0.04 to 76.30 ± 0.07. Ash content was recorded to be the lowest as 1.20 ± 0.04 in *S. manipurensis* and highest as 1.98 ± 0.01 in *N. stracheyi*. The total amino acids varied from 104.42 to 113.92 g/100 g. The total EAA was recorded in the range from 55.08 to 66.51 g/100 g and total non-essential amino acids in the range from 46.09 to 56.74 g/100 g. The most predominant amino acid in all the species was glutamic acid. Leucine, lysine, histidine, valine, threonine, phenylalanine and isoleucine were the abundantly observed EAA in all the fish species. They emphasized that this study could give important information about amino acid compositions in fish species, which could be served as good and unique sources for nutrients for the human diet.

Mohanty et al. (2014) studied amino acid compositions of 27 food fish species. The selected species were the Carps: *Cirrhinus mrigala, Catla catla* and *Labeo rohita*, catfishes: *Heteropneustes fossilis Clarias batrachus* and *Sperata seenghala*, the small indigenous fishes: *Anabas testudineus, Puntius sophore, Amblypharyngodon mola* (all fresh water fishes), and *Tenualosa ilisha* (anadromous), the marine fishes: *Stolephorus waitei, Thunnus albacares, Stolephorus commersonii, Nemipterus japonicas, Rastrelliger kanagurta, Sardinella longiceps, Epinephelus spp., Katsuwonus pelamis, Trichiurus lepturus*, and *Leiognathus splendens*, the cold water fishes: *Tor putitora, Oncorhynchus mykiss,* *Schizothorax richardsonii, Cyprinus carpio* and *Neolissochilus hexagonolepis*, and the shellfishes: *Perna viridis* and *Crassostrea madrasensis.* It was reported that crude protein content ranged from 11.0 ± 0.1 % in *Perna viridis* to 23.9 ± 0.1 % in *Thunnus albacares*. The essential amino acid, glutamic acid was found to be the highest in *Nemipterus japonicas* (16.55 ± 1.2 g/100 g), glycine was the highest in *Heteropneustes fossilis* (15.4 ± 3.6 g/100 g), leucine was the highest in *Stolephorus waitei* (10.4 ± 0.4 g/100 g), valine was the highest in *Nemipterus japonicas* (8.6 ± 1.3 g/100 g), histidine was the highest in *Rastrelliger kanagurta* (7.9 ± 0.6 g/100 g), tryptophan was the highest in *Tor putitora* (6.5 ± 0.9 g/100 g). This study showed that the marine fishes were rich in leucine, cold water fishes were rich in aspartic acid and lysine, small indigenous fishes were rich in histidine, the catfishes and carps were rich in glycine and glutamic acid, respectively.

Singh et al. (2016) studied the biochemical compositions of three freshwater fishes of Teleosts (*Clarias batrachus, Channa punctatus, Anabas testudineus*) from Berhampur University campus rearing pond. They observed that biochemical composition, protein and lipid vary among the fish species. The protein contents in the liver varied from 10.25 ± 0.52 to 13.92 ± 2.326 g/100 g, in pancreases it varied from 8.85 ± 0.67 to 11.4 ± 10.794 g/100 g, and in muscle it varied from 17.50 ± 0.865 to 19.49 ± 0.732 g/100 g. The protein contents of *Clarias batrachus, Channa punctatus* and *Anabas testudineus* in gills were 6.079 ± 2.472 g/100 g, 14.779 ± 1.084 g/100 g, 7.80 ± 0.596 g/100 g, respectively. The lipid contents *Clarias batrachus, Channa punctatus* and *Anabas testudineus* in liver were 1.08 ± 0.460 g/100 g, 1 .10 ± 0.118 g/100 g, 0.88 ± 0.462 g/100 g, in muscle were 1.46 ± 0.262 g/100 g, 1.44± 0.39 g/100 g, 1.19 ± 0.27 g/100 g, in pancreases 0.789 ± 0.371 g/100 g, 1.23 ± 0.484 g/100 g, 1.06 ± 0.298 g/100 g and in gills were 0.81 ± 0.109 g/100 g, 0.67 ± 0.192 g/100 g and 1.04 ± 0.328 g/100 g, respectively. They said that the variation may be due to age, size, sex, reproductive cycle and breeding season.

Chakraborty et al. (2018) studied nutritional analyses of indigenous food fish, *Chanda nama* consumed by the Bodos of Kokrajhar, Assam. Proximate data such as moisture, ash, total protein, total carbohydrate and total lipid contents were found to be 68.12 ± 0.06 %, 5.59 ± 0.02 %, 14.86 ± 0.04 %, 0.33 ± 0.04 % and 11.09 ± 0.07 % respectively. The amino acid profile revealed the fair content of essential amino acid L-histidine (8.36 ± 0.05 g/100 g). The fatty acid results showed the presence of palmitic acid (4.49 ± 0.01 g/100 g), oleic acid (1.94 ± 0.03 g/100 g) and stearic acid (1.43 ± 0.02 g/100 g) apart from various others. It was also reported that *Chanda nama* was rich source of iron (3.90 ± 0.02 mg/100 g), zinc (3.18 ±

0.02 mg/100 g), calcium (807 ± 0.02 mg/100 g) and phosphorus (2470 ± 0.02 mg/100 g). The vitamin A content (378.96 ± 0.03 µg/100 g) was also reported in the present study.

Fawole et al. (2007) investigated mineral and proximate composition of selected freshwater fishes *viz. Oreochromis niloticus, Sarotherodon galilaeus, Clarias gariepinus* and *Heterotis niloticus* from Nigeria. They examined appreciable concentrations of sodium, potassium, phosphorous, magnesium, calcium, and iron in all fishes and concluded that the fish species could be used as a good source of minerals. The species *O. Niloticus*, *C. gariepinus, H. niloticus,* and *S. galilaeus* showed the highest concentration of sodium such 0.80 %, 0.80 %, 0.74 % and 0.73 % respectively among the other minerals. The proximate composition results showed that crude protein ranged from 38.40 % in *O. niloticus* to 46.28 % in *H. niloticus*, crude fibre ranged from 0.10 % in *C. gariepinus* to 0.38 % in *O. niloticus,* Ash content ranged from 4.00 % in *C. gariepinus* to 9.00 % in *H. niloticus*, moisture content ranged from 5.80 % in *S. galilaeus* to 7.90 % in *H. niloticus,* dry matter ranged from 92.10 % in *H. niloticus* to 94.20 % in *S. galilaeus.*

Mazumder et al. (2008) studied the proximate profiles of small fishes from Bangladesh. The fish species selected for this study were Chapila (*Gudusia chapra*), Mola (*Amblypharyngodon mola*), Punti (*Puntius chola*), Batashi (*Pseudeutropius atherinoides*), Chanda (*Chanda nama*) and Kajuli (*Ailia coila*). They reported that proximate values were found to vary among different species. The moisture was found to be the highest in *C. nama* (78.62 %) and lowest in *A. coila* (65.88 %). Ash content was found to be the highest in *C. nama* (3.92 %) and lowest in *G. chapra* (1.55 %). Protein content found in *A. mola* was 18.46 %, *G. chapra* was 15.23 %, *P. chola* was 14.08 %, *C. nama* was 18.26 %, *P. atherinoides* was 15.84 % and in *A. coila* was 16.99 %, and the fat content was found as 4.10 %, 5.41 %, 3.05 %, 1.53 %, 2.24 % and 3.53 % in the six fish species, respectively.

Saoud et al. (2008) studied seasonal variation of nutritional compositions of two fish species *S. rivulatus* (Rabbitfish) and *D. sargus* (Whites Sea bream) from the eastern Mediterranean Sea. They observed that the proximate composition of both Rabbitfish and White Sea bream muscle tissues vary during different seasons. Species weight of Rabbitfish was found to be the highest to lowest accordingly in the month June to December containing 110.1 g and 32.2 g respectively. Moisture content of Rabbitfish ranged from 73.58 % in August to 79.11 % in March, protein ranged from 17.82 % in May to 22.44 % in June, lipid ranged from 1.15 % in February to 3.81 % in August and ash content ranged from 1.01 % in March to 2.27 % in August. Species weight of White Sea bream was found to be the highest to lowest accordingly in the month February to December containing 169.1 g and 70.8 g respectively. Moisture content of White Sea bream ranged from 76.24 % in February to 79.39 % in May, protein ranged from 18.11 % in March to 20.38 % in February, lipid ranged from 0.23 % in May to 2.27 % in October and ash content ranged from 1.54 % in October to 2.37 % in June. They also reported that fillet yield from Rabbitfish is greater (36.76 ± 0.67 %) than from White Sea bream (28.76 ± 0.41%).

Musa (2009) studied the nutritional composition of indigenous freshwater fish species, *Puntius Stigma* (male and female) found in Bangladesh. He investigated proximate compositions such as moisture, protein, lipid, ash, carbohydrate and some mineral compositions such as phosphorous, potassium, magnesium, calcium, zinc, copper, manganese, and iron along with the determination of some amino acids. Results recorded that the moisture (75.60 %) was found higher in female than the male, while protein (21.50 %), fat (2.70 %), ash (1.90 %) and carbohydrate (1.55 %) were found to be higher in male (*Puntius Stigma*). The mineral concentrations were observed to be higher in male. But Mn and Fe were reported to be lower in male. Except few essential amino acids all other amino acids were reported to be comparatively higher in male than female. So, they concluded that the nutritional values were higher in male *Puntius stigma* than in female.

Filho et al. (2010) studied the nutritional values of seven freshwater fish species from the Miranda River, Brazil. The selected fish species were *viz. Pimelodus argenteus, Pimelodus maculatus, Hemisorubim platyrhynchos, Pinirampus pirinampu, Paulicea luetkeni, Surubim lima* and *Ageneiosus brevifilis* for the study. They observed that the proximate composition of muscle tissue varied significantly among fish species. The total lipid showed the largest coefficient of variation (73 %) while protein content showed the smallest (4.5 %) among species. Palmitic acid (23.76–25.99 %) was the predominant SFA in all the species and oleic acid (16.09–32.90 %) was the most abundant MUFA. The total ω-6 PUFA (5.99–15.56 %) were found to be the predominant PUFA, except in *Ageneiosus brevifilis* (palmito), in which the total ω-3 PUFA predominated (10.30 %). They concluded that all the fish species had favorable indices of nutritional quality for the total lipids with respect to consumption as human diet.

Mohamed et al. (2010) studied the proximate, amino acids and mineral profiles of five commercial Nile fish species from Sudan. The selected species were *Bagrus bayad, Lates niloticus, Oreochromis niloticus, Tetraodon lineatus* and *Synodontis schall*. They recorded that the lipid content varied from 1.8 to 17.3 % and the moisture content ranged from 73 to 80%. Protein was found to be 59.8 % in *S. schall* and 77 to 79.1 % in the remaining species. The caloric value was found in between 357 to 425 kJ/100 g, which was found to be the highest in *B. bayad* and the least being in *T. lineatus*. Mineral results showed that potassium content varied from 33 to 41%, phosphorous from 25 to 36 %, selenium from 12 to 16%, calcium from 4 to 19 %, sodium from 2 to 10 %, and magnesium from 2 to 3 %; while zinc, iron, aluminium and copper were found to be present in trace amounts. They recorded eight EAA with the total amount varying from 961 to 2279 μg/g and lysine concentration was noticed to be the highest in all the species followed by leucine.

Effiong and Fakunle (2012) studied the proximate and mineral contents of traditional smoked fish species from Lake Kainji, Nigeria. The selected the fish species were *Latesniloticus, Clarias anguillaris* and *Synodontis membranaceusus*. They recorded that the moisture contents in all the samples were low with no significant differences (p>0.05). The crude protein content in fish sample was in the range of 26.54 ± 26 to 36.56 ± 0.22 %, while fat content was found to be in the range of 16.43 ± 0.18 to 24.18 ± 0.43 %. The highest protein was found in *Clarias anguillaris* and the highest fat was found in *Synodontis membranaceusus*. Ash content was in the range of 0.43 ± 0.23 to 4.41 ± 0.44 %. The results of the mineral contents indicated the phosphorous (108.14 ± 42.34 – 119.23 ± 54.64) and magnesium (79.10 ± 8.38 – 98.57 ± 12.8) to be the highest in all the three species and iron was detected to be the lowest in range of 9.84 ± 1.16 – 16.47 ± 2.18 among the species.

Zaman et al. (2014) studied the nutrient profiles of some marine and freshwater fishes of Bangladesh. They observed that Thai Sarpunti (17.5 ± 0.15 %) and Rui (16.82 ± 0.02 %) were the high protein fishes, and Thai Pangus (10.03 ± 0.1 %) and Thai Sarpunti (9.38 ± 0.37 %) were high fat fishes. High ash contents were observed in Poa (4.78 ± 0.92 %), Ganges Chapila (3.96 ± 0.51 %), and Thai Sarpunti (3.31 ± 0.14 %). High energy was found in Thai Sarpunti (157.02 ± 2.61 kcal/g) and Thai Pangus (151.59 ± 2.71 kcal/g). They reported that Ca rich fishes were Punti (1984.32 ± 1.1 mg/100 g), Mola (1267 ± 2.2 mg/100 g), Dhela (1717.8 ± 3.1 mg/100 g), Chapila (1100.6 ± 1.21 mg/100 g) and Thai Sarpunti (1373.9 ± 5.32 mg/100 g). K rich fishes were Taki (501.47 ± 2.9 mg/100 g), Coral (415.24 ± 2.8 mg/100 g). Na rich fishes were Thai Sarpunti (780.01 ± 3.8 mg/100 g), Ganges Chapila (415.32 ± 2.34 mg/100 g), Loitta (497.38 ± 4.21 mg/100 g), Mg was found high in Coral (187.98 ± 0.61 mg/100g), Punti (148.16 ± 0.62 mg/100 g), Datina (144.05 ± 0.35 mg/100 g), Kachki (143.49 ± 0.3 mg/100 g) fishes. Fe was found high in Chapila (15.95 ± 0.03 mg/100 g), Punti (10.31 ± 0.2 mg/100 g), Poa (7.01 ± 0.66 mg/100 g). Zn was detected in Thai Sarpunti (40.20 ± 0.34 mg/100 g), Poa (29.32 ± 0.32 mg/100 g). Mn was found the highest in Chapila (6.34 ± 0.04 mg/100 g).

Jabeen and Chaudhry (2016) studied the nutritional compositions of 7 freshwater fish species *viz. C. carpio, L. rohita, C. mrigala, A. aorsarwari, C. marulius, O. mossambicus,* and *W. attu*. They found that some nutrient contents of fish species vary based on the weight of the selected fish species. They showed that the total fat and ash contents were higher in the high weight (W2) fish species than the low weight (W1) category. While crude protein and total carbohydrates were higher in W1 than W2 category which was the highest in *W. attu* 80.5 % (W1) and *O. mossambicus* in 16.5 % (W1) respectively. The energy content was the highst in *C. marulius* 481.7 Kcal/100 g (W2). Highest amount of glutamic acid was found in *L. rohita* 125.5 mg/g (W1), lysine was found to be the highest in *L. rohita* 78.9 mg/g (W1).

Imre and Saglik (1998) investigated the fatty acid profiles and cholesterols of some Turkish fish species. They recorded 9 common fish species obtained from the central fish market in Istanbul and the species were *Dicentrarchus labrax, Dentex dentex, Pagellus erythrinus, Diplodus sargus, Mullus surmuletus, Solea solea, Scomber scombrus, Pomatamus saltatrix, Pomatomus saltatrix, Sardina pilchardus*. They observed that the amounts of cholesterol in fish lipids did not differ significantly and the total lipid found varied from 0.82 % (sole, *Solea solea*) to 16.96 % (sardine, *Sardina pilchardus*). The fatty acid *viz*. palmitic acid (19.2–26.6 %) and oleic acid (17.4–28.7 %) were the predominant fatty acids in all species. The amounts of EPA and DHA ranged from 0.7–8.3 % and 3.8–17.5 %, respectively. They concluded that red mullet (*Mullus surmuletus*), Sardine (*Sardina pilchardus*) and mackerel (*Scomber scombrus*) were the most appropriate pelagic species for a preventive diet.

Saify et al. (2003) studied the fatty acid profiles of fish liver oil of 2 marine fish species viz. *Carcharhinus bleekeri* and *Eusphyra blochii*. They observed a large variation between liver oils of sandbar shark and winghead shark i.e. lipid content in the liver of *Eusphyra blochii* was 66.19 % and that of *Carcharhinus bleekeri* 39.94 %. They reported that the saturated fatty acids in winghead shark's liver ranged from 56 % to 70.12 %. Among these, palmitic acid was the predominant which ranged from 36.63 % to 46.97 %, while stearic acid ranged from 9.34 % to 17.49 %. PUFAs ranged from 4.25 % to 15.21 % in which EPA ranged from 0.41 % to 1.65 % and DHA ranged from 0.24 % to 3.07 %. The saturated fatty acids in Sandbar shark's liver ranged from 34.77 % to 68.24 %, and here also palmitic and stearic acids were the major saturated fatty acids that ranged from 33.50 to 56.46 % and 7.99 to 11.55 %, respectively. PUFA ranged from 1.08 % to 7.38 % in which EPA and DHA ranged from 0.16 to 0.85 % and 0.06 to 2.39 % respectively.

Shamsudin and Salimon (2006) studied the total lipid and fatty acid profiles in *Seriola nigrofasciata* (aji-aji fish) from Malaysia. They extracted fish oil using Soxhlet with a 2:1 mixture of chloroform and methanol. Results demonstrated that the lipid consists of higher saturated fatty acids (45.8 ± 1.8 %) compared to MUFAs (32.4 ± 0.5 %) and PUFAs (1.0 ± 0.2 % of ω-6 PUFAs and 9.8 ± 0.5 % of ω-3 PUFAs). They also reported that aji-aji fish oil had relatively higher ω-3 PUFAs compared to other local fish oils.

Soltan and Gibson (2008) studied the levels of ω-3 fatty acids from Australian seafood. They recorded a total of 26 species of South Australian fishes. They reported that ω-3 fatty acids varied from 17.7 % to 53.7 % and DHA (22:6 ω–3) ranged from 9.5 % to 47.1 % and concentrations of total ω–6 fatty acids ranged from 2.3 % to 20.2 %.

Ugoala et al. (2008) studied the fatty acid components of some freshwater and marine fish species. They observed that in freshwater fish species, the saturated fatty acids (SFA) ranged from 9 % to 76 %, and among these the major SFA were C14:0 and C16:0. The monounsaturated fatty acids (MUFA) ranged from 10% to 90% with C18:1 as the prominent MUFA. In all the fish species, the dominant PUFA was ω-6 series and were found chiefly in C18:2 fatty acids. The essential fatty acid compositions were found as C18:3 ω-3 and C18:2 ω-6 and found in the tilapia species. The branched chain fatty acids were 51 %, 44 % and 31 % in Sarotherodon *galilaeus, Oreochromis niloticus* and *Lates niloticus* respectively. They concluded that the marine fishes have regular pattern of fatty acid composition with better sources of ω-3 essential fatty acids while freshwater fishes were good source of ω-6 essential fatty acid.

Stancheva et al. (2010) studied the fatty acid profiles and fat-soluble vitamins of Sprat (*Sprattus sprattus*) and Goby (*Neogobius rattan*) from Bulgarian Black Sea. They reported that MUFA was 26.93 % in Sprat and 30.38 % in Goby. Palmitoleic (C 16:1) and oleic (C 18:1) acids were dominant MUFA. High levels of PUFA including eicosapentaenoic (C 20:5, EPA) and docosahexaenoic (C 22:6, DHA) acids were found in Goby (37.60%). The results of fat-soluble vitamins showed the differences between Sprat and Goby. The higher levels of all-trans-retinol and cholecalciferol were found in Sprat 33.18 ± 1.55 μg/100 g and 10.51 ± 0.54 μg/100 g respectively. The α-tocopherol content was higher in Goby fish (614.90 ± 40.30 μg/100 g). So, they concluded that both fish species were good sources of ω-3 fatty acids, vitamins A, D3 and E.

Nielsen et al. (2011) studied the fatty acid profiles in the white muscle and heart tissue of 13 ecoforms/species of Lake Baikal fish belonging to *Salmonidae, Esocidae, Cyprinidae,* and *Percidae* families. They reported that the total saturated fatty acid concentrations in heart tissue varied from 27.6 ± 2.99 % in Dace to 35 ± 2.84 % in Omul (Littoral), total MUFA in heart tissue varied from 21.7 ± 1.46 % in Dace to 32.9 ± 2.84 % in Whitefish, total PUFA ranged from 27.4 ± 6.41 % in Whitefish to 46 ± 6.13 % in Dace, ω-3 fatty acids ranged from 16.7 ± 3.87 % in Ide to 33.5 ± 5.64 % in Dace, ω-6 fatty acids ranged from 8.7 ± 0.98 % in Whitefish to 17.3 ± 3.51 % in Perch. The total saturated fatty acids in white muscle varied from 22.47 ± 0.55 % in Pike to 31.46 ± 2.52 % in Omul (Deepwater), total MUFA ranged from 10.99 ± 0.62 % in Omul (Deepwater) to 38.38 ± 12.4 % in Big golomyanka, total PUFA ranged from 27.65 ± 4.85 % in Big golomyanka to 60.34 ± 3.18 % in Grayling, ω-3 fatty acids ranged from 17.78 ± 4.46 % in Big golomyanka to 53.36 ± 2.62 % in Grayling and ω-6 fatty acids ranged from 7.11 ± 1.85 % in Whitefish to 22.87 ± 1.48 % in Die. It also reported that ω-3/ω-6 PUFA ratio ranged between 1.3 and 3.2 in heart tissue and 1.4 and 6.6 in white muscle.

Luczynska et al. (2014) investigated the fatty acid compositions in freshwater and marine fishes from Northeastern Poland. They reported that the freshwater fish showed 25.69–42.18 % of SFA, 34.90–43.79 % of MUFA, 8.46–16.32 % of ω-6 PUFA and 5.01–20.43 % ω-3 PUFA, while marine fish species contained 18.53–32.77 % of SFA, 17.95–49.89 % of MUFA, 3.40–11.51 % of ω-6 PUFA, and 18.74–45.42 % ω-3 PUFA.

Ibhadon et al. (2015) performed a comparative analysis of proximate, fatty acid and amino acid compositions of African Catfish (*Clarias gariepinus*). They reported that moisture content varied from 69.3 to 79.3 %, crude protein from 10.40 to 11.43 %, lipid content from 1.15 to 2.08 % and ash content from 1.02 to 1.22 %. They reported 7 major fatty acids and 17 amino acids in the fish species and found that the cat fishes raised in farm had a higher amount of total amino acids, while cysteine and histidine were low in both farm-raised and wild catfish samples. They concluded that both wild and farm-raised catfish was beneficial for health.

Baki et al. (2015) investigated the biochemical, fatty acid and amino acid compositions of cultured and wild sea bass (*Dicentrarchus labrax*). They recorded biochemical compositions such as crude protein, crude fat and moisture contents of wild sea bass to be 19.13 %, 18.0 % and 8.90 % respectively and that of cultured sea bass were found as 10.30 %, 68.37 % and 68.83 % respectively. EAAs were found to be 6921 ± 11 and 7360.5 ± 266.5 mg/100 g in wild and cultured sea bass, respectively. Saturated fatty acid (SFA) was 26.50 ± 0.06 % and 25.11 ± 0.01 % in wild and cultured sea bass, respectively. The MUFAs were 27.55 ± 0.22 % and 30.14 ± 0.02 %, and PUFAs were 35.06 ± 0.02 % and 33.82 ± 0.12 % in wild and cultured sea bass respectively. They reported that food composition of cultured sea bass had high quality of nutritional value.

Rodrigues et al. (2017) studied the fatty acid and proximate compositions of 5 Brazilian freshwater fishes viz. *Cichla ocellaris* (CO), *Brycon cephalus* (BC), *Prochilodus lineatus* (PL), *Pseudoplatystoma corruscans* (PCO) and *Leporinus friderici* (LF). They reported that moisture contents of all 5 species varied from 72.61 ± 0.64 % in BC to 78.27 ± 0.25 % in CO, protein ranged from 19.72 ± 0.53 % in LF to 24.50 ± 0.84 % in CO, lipid content varied from 0.54 ± 0.18 % in PCO to 2.72 ± 0.36 % in BC, and ash content ranged from 1.07±0.03 % in BC to 1.40±0.06 % in PCO. The highest total SFA value was observed in PCO (24.80 ± 0.39 %), whereas the lowest was observed in BC (17.01 ± 1.39 %). Among SFA, palmitic acid (C16:0) was the most predominant SFA in all the species, varying from 13.01 ± 1.29 % in BC to 22.35 ± 0.70 % in PL. Total MUFA ranged from 22.45 ± 1.51 % in PL to 28.09 ± 0.97 % in LF, total PUFA ranged from 50.91 ± 0.73 % in LF to 58.70 ± 1.41 % in BC, total ω-3 fatty acids ranged from 22.29 ± 0.58 % in LF to 32.97 ± 0.80 % in CO, total ω-6 fatty acids ranged from 21.83 ± 1.62 % in CO to 28.63 ± 0.16 % LF, and EPA+DHA ranged from 22.04 ± 0.57 % in LF to 32.76 ± 0.87 % in CO, DHA/EPA ratio ranged from 2.44 ± 0.07 % in LF to 3.63 ± 0.89 % in BC.

Ram et al. (2018) studied the fatty acid profiles of freshwater fishes from Bukit Merah Reservoir, Malaysia. They reported a total of 7 freshwater fish species which are edible *viz.* Javanese barb (*Barbonymus gonionotus*), tinfoil barb (*Barbonymus schwanenfeldii*), beardless barb (*Cyclocheilichthys apogon*), hampala barb (*Hampala macrolepidota*), glassfish (*Oxygaster anomalura*), horseface loach (*Acantopsis dialuzona*) and striped snakehead (*Channa striata*) which belonged to 3 families such as *Cyprinidae* (5sp.), *Channidae* (1 sp.) and *Cobitidae* (1 sp.). They observed that the species horseface loach recorded the highest total saturated fatty acids (43.1 %), while the highest MUFA (38.4 %) and PUFA (26.8%) were recorded in the striped snakehead and beardless barb, respectively. They also reported that the muscle of *Cyprinid* fish possessed significant amount of ω-3 long chain PUFA compared to fish from *Cobitidae* and *Channidae* families. They mentioned that the ω-3 PUFA in the fish muscle differs as per their feeding habits.

Priatni et al. (2018) investigated the protein and fatty acid profiles of marine fish species from Java Sea, Indonesia. The investigated nine marine fish species were *Leiognathus equulus, Mystacoleucus padangensis, Nemipterus hexodon, Oxyeleotris marmorata, Pampus argenteus, Selaroides leptolepis, Terapon jarbua, Tetraodontidae, Trichiurus lepturus.* They reported that the total protein amount varied from 61.07 % (*Pampus argenteus*) to 86.56 %

(*Tetraodontidae*) and the total lipid content ranged from 1.73 % (*Tetraodontidae*) to 9.82 % (*Leiognathus equulus*). The SFA of fishes varied from 1094.03–4233.03 μg/g. MUFA (oleic acid) content of all fish species varied from 257.91-1216.06 μg/g. PUFA (linoleic acid) contained in 3 fish species *viz. Selaroides leptolepis* (171.36 μg/g), Tetraodontidae (140.35 μg/g) and *Oxyeleotris marmorata* (249.40μg/g).

Osibona et al. (2009) studied the proximate, amino acid and fatty acid profiles of two freshwater fishes *viz. Tilapia zillii* and *Clarias gariepinus* from Lagos State, Nigeria. They reported the composition (%) of individual fatty acids as a ratio of total muscle lipids of *C. gariepinus* that ranged from 0.1 % to 26.0 % and that of *T. zillii* from 0.1 % to 32.2 %. The highest amounts were myristic acid (C14:0, 4.2–5.2 %), palmitic acid (C16:0, 22.0–32.2 %), palmitoleic acid (C16:1, 3.6–13.2 %), heptadecanoic acid (C17:0, 0.7–3.0 %), stearic acid (C18:0, 8.1–9.5 %), linoleic acid (C18:2, 1.4–12.3 %), oleic acid (C18:1). The most dominant amino acids found were aspartic acid, glutamic acid, lysine and leucine ranging from 9.49 % to 18.16 %. They also reported the ratio of ω-3/ω-6 fatty acids that was less than 1 in *C. gariepinus* while in *T. zillii* it was 2.70.

Erkan et al. (2010) studied the effect of frying, grilling and steaming on amino acid composition of Marine fishes. They reported that moisture, fat, ash and carbohydrate contents of raw fish ranged from 48.01 to 83.05 %, 0.87 to 30.48 %, 1.10 to 1.61 %, and from 0.09 to 8.70 %, respectively. All the fresh fishes investigated were high in protein (11.20–17.14 g/100 g). Wide variations in protein contents (18.11–25.65 g/100 g) between the methods of cooking and species were observed. Essential, semi-essential and non-essential amino acids were detected in all fish species. The results indicated that the changes in amino acid and proximate content were found to be significant for all cooking methods in all fish species. Cooking significantly increased the contents of essential, semi-essential and other amino acids compared with raw fish species. They also observed that fried fish had intermediate fat values, whereas grilled and steamed fishes had a comparatively low value.

Osibona (2011) studied the compositions of proximate, amino acids and fatty acids of some fish species of Lagos, Nigeria. They investigated proximate profile of the freshwater species and found to be 19.64 % protein, 1.15 % lipid, 76.71 % moisture and 1.23 % ash for *Clarias gariepinus*, and also reported 19.55 % protein, 0.96 % lipid, 76.75 % moisture and 1.11 % ash for *Tilapia zillii*. The marine water fish species *Pentanemus quinquarius* was found to contain 19.80 % protein, 0.40 % lipid, 72.63 % moisture and 1.13 % ash, while *Pseudotolithus typus* was found to contain 19.86 % protein, 1.06 % lipid, 75.40 % moisture and 1.17 % ash for. The EAA and fatty acids (DHA and EPA) were also detected in the species.

Shi et al. (2013) reported the nutritional compositions of juvenile bighead carp (*Aristichthys nobilis*) and paddlefish (*Polyodon spathula*). They observed that moisture, crude protein, crude fat and ash contents of the Juvenile bighead carp and Juvenile paddlefish muscle were 78.87 ± 0.67 g/100 g and 78.86 ± 1.03, 15.89 ± 0.68 g/100 g and 13.98 ± 0.72 g/100 g, 1.69 ± 0.06 g/100 g and 4.94 ± 0.35 g/100 g, 1.24 ± 0.08 g/100 g and 0.86 ± 0.09 g/100 g. Total amino acid was observed higher in bighead carp (14.97 ± 0.40 g/100 g) than paddlefish (12.72 ± 0.36 g/100 g), essential amino acids (EAAs) was also higher in bighead carp (5.92 ± 0.11 g/100 g) than paddlefish (5.10 ± 0.21 g/100 g), delicious amino acids (DAAs) were higher in bighead carp (6.71 ± 0.32 g/100 g) than paddlefish (5.62 ± 0.16 g/100 g). The total SFA was higher in paddlefish (17.09 ± 0.30 g/100 g) than bighead carp (5.71 ± 0.20 g/100 g). Among SFA, palmitic acid was the most predominant SFA found in paddlefish (11.41 ± 0.34 g/100 g). The total MUFA was found higher in paddlefish (15.86 ± 0.47 g/100 g) than bighead carp (4.44 ± 0.07 g/100 g), the total PUFA was found higher in paddlefish (16.40 ± 0.28 g/100 gm) than bighead carp (6.74 ± 0.13 g/100 g), EPA was found higher in paddlefish (5.53 ± 0.30 g/100 g) than bighead carp (2.08 ± 0.14 g/100 g), DHA was found higher in bighead carp (2.01 ± 0.06 g/100 g) than paddlefish (1.48 ± 0.23 g/100 g).

Tasbozan et al. (2013) studied the proximate and amino acid profies of 5 different Tilapia species *viz. Tilapia rendalli, juvenile Oreochromis aureus, Tilapia zillii, Oreochromis niloticus* and *Tilapia spp.* from the Cukurova Region, Turkey. The results showed that the dry matter, protein, lipid and ash contents ranged in species *Tilapia spp.* and *Tilapia rendalli* were 22.47 ± 1.01 % and 26.06 ± 0.22 %, 18.75 ± 0.01 % and 20.52 ± 0.47 %, 2.64 ± 0.07 % and 3.52 ± 0.22 %, 1.10 ± 0.01 % and 1.24 ± 0.01 %, respectively. The total EAAs ranged from 34.82 ± 1.47 g/100 g in *Tilapia spp.* to 42.17 ± 1.27 g/100 g in *T. zillii.*

Gunlu and Gunlu (2014) studied the taste activity value, free amino acid content and proximate composition of Mountain trout (*Salmo trutta macrostigma Dumeril*, 1858) muscles of Turkey. They reported that the moisture, protein, fat and ash contents were found in the ranges of 75.49 to 79.59 %, 16.94 to 19.97 %, 1.58 to 3.75 % and, 1.39 to 1.56 %, respectively. It was reported that the amounts of non-essential free amino acids were higher than the essential amino acids. They reported that the amino acids like glutamic acid, methionine, glycine, aspartic acid and lysine showed high taste activity values. Therefore, these showed strong taste impacts on the mountain trout meat flavour.

Tenyang et al. (2014) studied the chemical, fatty acid, amino acid and mineral profiles of 6 fish species *viz*. Belt (*Trichius Lepterus*), Herring (*Clupea Harengus*), Catfish (*Arius Maculatus*), Disc (*Symphysadon Discus*), Mullet (*Semotilus atromaculatus*) and Red carp (*Cyprinus Carpio*) from Cameroon. They reported the total lipid contents that ranged from 8.9 % to 23.0 % and crude ash content which varied from 10.7 % to 19.4 %. The abundant fatty acids in all species were the SFA ranging from 45.5 to 54.9%, and palmitic acid was the predominant saturated fatty acid in all fishes ranging from 26.7 to 34.0%. All these fishes contained amino acids. The mineral analysis showed the high levels of Ca, K and Mg. Therefore, they concluded that all these species were good sources of fatty acid, protein, DHA, EPA, and minerals which play a vital role in keeping good health.

Lukasik et al. (2016) studied the free amino acid content in muscle tissue of bighead carp and wels catfish. They reported different concentrations of free amino acids such as methionine (21 %), alanine (23 %), phenylalanine (28 %), taurine (31 %), arginine (41 %), glycine (52 %), serine (60 %), asparagine (67 %) and histidine (96 %) which were lower in wels catfish than in bighead carp. The concentrations of free amino acids were found higher in wels catfish than in bighead carp by 25–95 % for valine (25 %), cysteic acid (26 %), ethanoloamine (35 %), isoleucine (46 %), leucine (51 %), glutamic acid (52 %), theronine (57 %), aspartic acid (59 %), α-aminobutyric acid (59 %), cystationine (85 %), γ-aminobutyric acid (92 %), β-alanine (94 %) and glutamine (95 %).

ElShehawy et al. (2016) studied the fatty acid and amino acids profiles of commonly consumed fish from Saudi Arabia. The selected species were sabaki tilapia (*Oreochromis spilurus*), Indian oil sardine (*Sardinella longiceps*), golden thread fin bream (*Nemipterus japonicas*), grey mullet (*Liza ramada*), Asian seabass (*Lates calcarifer*), gilt head bream (*Sparus aurata*), job fish (*Apharus rutilanus*), dusky grouper (*Epinephelus marginatus*), spangled emperor (*Lethrinus nebuloses*), half spotted grouper (*Cephalopholis hemistiktos*) and rusty parrot fish (*Scarus* ferrugineus). They reported the results like essential amino acids (EAA) such as lysine (4.47–6.28 %), leucine (4.14–5.80 %) and valine (3.23–4.37 %). The total PUFA ranged from 20.48 ± 1.53 % in Sabaki tilapia to 43.19 ± 0.17 % in golden thread fin bream. They concluded that the studied fish species were considered vital sources of essential amino acids, polyunsaturated fatty acids especially DHA, ω-3 fatty acid and suggested to change the nutritive pattern of people in Saudi to encourage them to increase their fish consumption.

Funmilayo (2016) studied the proximate and amino acid profiles of Snakehead (*Parachanna obscura*), African pike (*Hepsetus odoe*) and Mudfish (*Clarias gariepinus*) from

Igboho dam, Nigeria. It was noticed that the species *viz. Parachanna obscura* contained the highest protein content (20.77 ± 0.08 %) and the highest fat (1.81 ± 0.02 %). The species *Clarias gariepinus* contained the highest moisture value (76.85 ± 0.01 %) and the highest amount of essential amino acid was recorded in *Hepsetus odoe* (9.90 ± 0.24 g/100 g). This investigation showed that the reported nutritional values would be useful in serving consumers for choosing the fishes for their nutritional benefits and will also provide an update to the database of food composition.

Martins et al. (2017) studied the chemical composition of different muscle zones in Pirarucu (*Arapaima gigas*). They reported that the ventral dorsal and tail muscle zones showed similar moisture (76.5–78.2 %), protein (17.8–18.9 %), lipids (1.0–1.5 %) and ash (0.9–1.2 %) contents. The ventrecha zone showed 25.8 % of protein and lipids of 17.1 %. Lipids content presented 42.7 % of SFA and 57.3 % of unsaturated fatty acids. Minerals observed in fish muscle were Na (65.1–175.5 mg/100 g) and K (183.5–288.6 mg/100 g). The main amino acid detected in fish muscle was glutamic acid (3027.6 mg/100 g), which presented 48 % of EAA. They reported that amino acids such as glutamic acid, lysine and aspartic acid were the main amino acids observed in Pirarucu muscle.

Ogundiran (2017) reported proximate composition study of *Phago loricatus, Laeviscutella dekimpei, Cithrarinus latus* and *Chelaethiops bibie* that showed encouragingly high crude protein value representing 23.21 %, 19.18 %, 41.22 % and 21.01 % respectively. *Phago loricatus* contained the highest leucine (70.00 ± 1.01 mg/kg). Minerals were also studied and the highest concentrations were recorded in *Phago loricatus* with the exception of Ca that has the highest value of 155.11 ± 1.22 mg/kg in *Laeviscutella dekimpei.*

Ahmed et al. (2017) investigated the mineral and proximate compositions of 6 fish species viz. *Hydrocynus froskalii, Bagrus bayad, Lates niloticus, Oreochromis niloticus, Labeo niloticus* and *Synodontis schall* from Jebl Awlia reservoir, Sudan. They reported the amount of protein in the range of 71.46 %–89.13 %, crude fat in the range of 6.34 %–9.66 %, moisture in the range of 75.33 %–79.33 % and ash in the range of 3.83 %–7.07 %. They also reported the mineral contents like potassium (200.0–774.0 ppm), calcium (195.0–246.0 ppm), sodium (184.0–211.0 ppm), magnesium (144.0–105.0 ppm) and phosphorus (90.0–240.0 ppm). The zinc and iron were found to be present in trace amounts.

Atma (2017) studied the amino acid and proximate profiles of fish bone gelatin from warm-water species and the selected fish species were grass carp, pangasius catfish, catfish, lizard fish, tiger-toothed croaker, pink perch, red snapper, brown spotted grouper and king weakfish. It was observed that 5 dominant amino acids were noticed in fish bone gelatin *viz.*

glycine (21.2–36.7 %), proline (8.7–11.7 %), hydroxyproline (5.3–9.6 %), alanine (8.48–12.9 %) and glutamic acid (7.23–10.15 %). It was reported that glycine was detected to be the highest amino acid in most of the fishbone gelatin. Methionine was relatively high in pangasius catfish and histidine was occurred in low concentration in most of the species and almost un-detectable in catfish. The proximate composition result revealed that fishbone gelatin from Pangasius catfish showed the highest protein content, King weakfish and Lizard fish exhibited the highest hydroxyproline and amino acid compositions among others. This study also reported that fish bone gelatin from warm-water fishes has a superior amino acid composition than cold-water fishes.

Rahman and Chowdhury (2018) studied the amino acid profiles of 5 marine fish species viz. *Lates calcarifer, Pampus chinensis, Johnius argentatus, Lepturacanthus savala* and *Harpodon nehereus* from Bangladesh. They could detect a total of 14 amino acids, of which 8 were EAAs and 6 were NEAAs. Results showed that EAAs such as histidine and isoleucine were found maximum among the other EAAs that ranged from lower to higher in species *H. nehereus* and *L. savala* were 419.58 ± 2.22 g/100 g and 884.5 ± 10.15 g/100 g, 307.84 ± 5.18 g/100 g and 640.9 ± 1.30 g/100 g, respectively. So, they concluded that the selected species showed good levels of EAA.

Biswas et al. (2018) reported a comparative study on proximate composition and amino acids of probiotics treated and non-treated Cage Reared Monosex tilapia *Oreochromis niloticus* in Dekar haor, Sunamganj district, Bangladesh. Here, Cage farming was done under four treatments as T1 (biozyme), T2 (rapid grow), T3 (miracure probiotics) and T4 (control). They observed that the moisture content in tilapia ranged from 62.92 ± 0.04 % to 68.09 ± 0.02 %, ash content ranged from 1.15 ± 0.04 % to 1.83 ± 0.02 %, protein content ranged from 21.22 ± 0.03% to 25.28 ± 0.05 % and lipid concentration varied from 2.07 ± 0.04% to 5.43 ± 0.03 %. The highest essential amino acid lysine was found in T3 (miracure probiotics) (1.71 ± 0.01 %) and the highest content of non-essential amino acid glutamic acid was found in T3 (miracure probiotics) (3.01 ± 0.04%).

Elaigwu (2019) studied the proximate and amino acid profiles and chemical indices in 5 freshwater fish species of Tiga Dam Reservoir, Nigeria. The selected species were *Bagrus bayad, Schilbe mystus, Oreochromis niloticus, Petrocephalus bane* and *Clarias anguillaris*. They observed that proximate composition varied in all fish species such as moisture (4.79–9.52 g/100 g), crude protein (42.20–57.71 g/100 g), ash content (0.90–12.51 g/100 g), ether extract (3.41–9.93 g/100 g), crude fibre (0.62–5.08 g/100 g), nitrogen extract (12.28–42.70 g/100 g) and dry matter (90.48–95.21 g/100 g). A total of 9 EAAs were found in all the fish species and these were lysine (4.21–6.34 g/100 g), histidine (1.96–4.30 g/100 g), arginine (5.80–8.21 g/100 g), threonine (1.93–5.05 g/100 g), valine (2.91–5.53 g/100 g), methionine (1.74–3.80 g/100 g), isoleucine (2.04–3.37 g/100 g), leucine (3.64–7.18 g/100 g) and phynylalanine (1.90–4.23 g/100 g). They reported that *P. bane* contained high concentration of crude protein, *S. mystus* contained highest EAA and lipid content. They also reported that *C. anguillaris* contained the best amino acid content and highest calorific value.

Jovel et al. (2016) studied the characterization of gut microbiome using two approaches 16S ribosomal RNA (rRNA) gene amplicons and shotgun metagenomics approaches. They conducted a literature review and used their own data to determine which approaches work best. So, they emphasized various techniques for the analysis of bacterial communities within samples (α-diversity) and between samples (β-diversity) and finally, they demonstrated a techniques which was used to infer the metabolic capabilities of a bacteria community from these 16S and shotgun data. Also, they suggested that 16S rRNA gene was well suited than Shotgun metagenomics based on cost because Shotgun approach is more expensive than 16S rRNA gene amplicon.

Gainza et al. (2017) studied the characterization of intestinal tract bacterial microbiota composition of *Penaeus vannamei* by comparing two Shrimp-farming phases: nursery and harvest. They examined sequencing amplicons V2–V3 of the 16S rRNA using Ion Torrent technology. They found Archaea sequences in both phases but the main differences were observed at the phylum level i.e. in the nursery phase, the prevailing phyla were CKC4 (37.3 %), Proteobacteria (29.8 %), Actinobacteria (11.6 %), and Firmicutes (10.1 %) and in the harvest phase, the prevailing phyla were Proteobacteria (28.4 %), Chloroflexi (19.9 %), and Actinobacteria (15.1 %). At the genus level, it showed greater relative abundances of CKC4 uncultured bacterium (37 %) and Escherichia-Shigella (18 %) microbiota from the nursery phase.

Rose et al. (2019) studied a comparative analysis of metagenomic DNA extraction methods from gut microbiota of zebrafish (*Danio rerio*) for downstream next generation sequencing. This study portrayed an augmented method for gut metagenomic DNA isolation from zebrafish gut with focused on obtaining effective yield and purity. They used 16S rRNA gene-specific universal primers 5′AGAGTTTGATCCTGGCTCAG 3′ and 5′ ACGGCTACCTTGTTACGACTT 3′ for PCR amplification. The three methods using the kit QIAamp DNA Stool Mini Kit (Qiagen, Valencia, CA, USA) were evaluated, of which the modified kit method was an affordable and feasible method for isolation of metagenomic

DNA from zebrafish. This modified protocol can be used for isolating quality DNA which is an important parameter for downstream applications such as PCR, cloning, NGS and others.

Garcia et al. (2018) studied the microbiome differences between river dwelling and cave-adapted populations of the fish *Astyanax mexicanus* (De Filippi, 1853). In the study, stomach microbiomes were assayed using Ion 16S metagenomic kit with the help of seven hypervariable regions. Sequencing was performed on an Ion Torrent PGM, using Ion 316 chip kit v2 BC with 4 and 8 chips. The goal of this study was developed in order to evaluate the potential response of microbiota to contrasting environmental conditions and physiological adaptations of the host. Results showed that a high diversity was observed across samples, including 16 phyla, 120 families and 178 genera. *Gamma proteobacteria, Firmicutes, Bacteroidetes* and *Betaproteobacteria* were seen to be the most dominant phyla across the samples. It was observed that the relative abundance of the core OTUs at genus level were highly contrasting among populations. So, they concluded that the microbiota of *A. mexicanus* is related to water parameters, but not linked with the contrasting conditions of the habitat.

Rimoldi et al. (2018) studied the next generation sequencing for gut microbiome characterization in rainbow trout (*Oncorhynchus mykiss*) fed animal by-product meals as an alternative to fishmeal protein sources. The total bacterial genomic DNA from the entire collected fecal sample was extracted by QIAamp DNA Stool Mini Kit and High-throughput amplicon sequencing of 16S rRNA gene and used to study the gut microbial profile. A total of 2,701,274 reads were taxonomically classified, corresponding to a mean of 96,474 ± 68,056 reads per sample were obtained and 5399 OTUs (Operational Taxonomic Units) were identified, which predominantly mapped to the phyla of *Firmicutes, Proteobacteria, Bacteroidetes* and *Actinobacteria*. So, from this study they concluded that animal by-product meals showed a good result in terms of growth performances and also it did not induce significant changes in gut microbial richness.

Hsu et al. (2018) revealed the compositions of the intestinal microbiota of three *Anguillid* eel species using 16S rDNA sequencing. They selected the three eel species *viz. A. japonica, A. marmorata* and *A. bicolor pacifica* from Taiwan. The microorganisms were isolated from intestinal mucus samples of these three eel species. The diversity, abundance of the intestinal microbiome and compositions of all the libraries were identified. They reported that the composition of intestinal microbiome of eel would be affected by the waters and the characteristics of different eel species. Results showed that the most predominant genera of the intestinal microbiome of these three eel species were *Cetobacterium, Clostridium,* *Shewanella, Acinetobacter* and *Bacteroides* which seemed to have great potential as the probiotics. So, they suggested promoting the practical application of these candidate probiotics for improving the techniques of eel farming.

Perez et al. (2019) studied the gut microbiome analysis in adult tropical gars (*Atractosteus tropicus*) from Mexico. In this study, they reported the whole taxonomic composition of microbial communities in gut contents of adult's *A. tropicus,* by sex (female/male) and origin (wild/cultivated). Here, the whole genomic DNA was extracted by QIAamp DNA Stool Mini Kit and metagenomic DNA was used for high throughput 16S rDNA profiling by amplifying the hypervariable regions of the bacterial gene. It was recorded 364,735 total paired-end reads, 27 obtained on an Illumina MiSeq sequencing platform belongs to 508 identified genera. The most and least abundant were *Cetobacterium, Edwardsiella, Serratia, Clostridium sensu stricto, Paludibacter* and *Campylobacter, Snodgrassella, Albirhodobacter, Lentilitoribacter.* They detected that, by sex and origin, *Proteobacteria, Fusobacteria, Firmicutes* and *Bacteroidetes* phyla were the core gut microbiome of the adult's *A. tropicus.*